Analyzing Motor Vehicle Injuries with the Connecticut Crash Outcome Data Evaluation System GIS

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Abstract

The Connecticut Crash Outcome Data Evaluation System (CODES) geographic information system (GIS) is a statewide GIS application developed by the Injury Prevention Program of the Connecticut Department of Public Health for viewing, analyzing, and reporting information on motor vehicle collisions and the medical care provided to persons injured in them. The Connecticut CODES Project was funded by the National Highway Traffic Safety Administration in 1997. Connecticut is one of a number of states funded to link medical outcome data with motor vehicle collision data. By linking collision, vehicle, and human behavior characteristics to their specific medical and financial outcomes, the project can identify prevention factors. The GIS component of the project uses collision data for 1995 and 1996 from police accident reports coded by the Connecticut Department of Transportation, as well as hospital discharge and emergency department data from the Connecticut Healthcare Research and Education Foundation. The GIS stores these data in a relational database that links to a GIS database of collision locations. The application supports a wide range of GIS functions, including geocoding, querying, and color mapping, through a specially designed user interface. The Injury Prevention Program is using the CODES GIS to identify high-frequency collision locations and to evaluate the effectiveness of safety belts, child passenger safety seats, and motorcycle helmets in preventing (and reducing the severity of) injuries and deaths resulting from motor vehicle collisions. A public-use version of the application and databases enables other stakeholders to retrieve, analyze, and map data of special interest.

Keywords: motor vehicle injury, injury surveillance, injury prevention, data linkage

Introduction

Efforts to reduce deaths and injuries from motor vehicle collisions by improving protection systems like safety belts have been effective, but injuries resulting from crashes continue to be a major public health problem. The focus of government agencies responsible for improving highway safety has broadened from documenting the occurrence of injuries to monitoring the injuries and the subsequent medical care outcomes and health care costs, to establish priorities for prevention. A congressional mandate was included in the Intermodal Surface Transportation Efficiency Act of 1991 calling for a study of the benefits of safety belts and motorcycle helmets. According to the mandate, this study was to go beyond the analysis of fatal injuries to document the severity of non-fatal injuries and the medical care costs associated with treating them.

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Beginning in 1992, the National Highway Traffic Safety Administration (NHTSA) made grants to seven states to implement Crash Outcome Data Evaluation Systems (CODES) projects that would link motor vehicle crash data collected at the state level with medical outcome data (1). In 1997, the Connecticut Department of Public Health received an award to develop a CODES project. This paper describes the Connecticut CODES geographic information system (GIS), a system designed to provide an environment for viewing and analyzing the linked motor vehicle and medical outcome database created for the Connecticut CODES project.

An important NHTSA requirement for CODES projects is creation of a public-use version of the linked database. Although GIS analysis was not specifically required by NHTSA, a number of states have chosen to develop GIS components as part of their CODES projects. This choice reflects a growing interest in the role that GIS might play in motor vehicle injury analysis in the United States and in other countries (2,3). Using GIS in the study of motor vehicle injury supports injury surveillance programs that monitor injury patterns by type and location of occurrence, supports epidemiological analysis through development of more accurate numerators and denominators for particular kinds of crash events, and supports implementation and evaluation of site-specific intervention strategies.

Materials and Methods

The Connecticut CODES project links statewide crash data for 1995 and 1996 to emergency department, hospital inpatient, and trauma records maintained by the Connecticut Health Research and Education Foundation, as well as to mortality records maintained by the Vital Records Section of the Connecticut Department of Public Health. The crash data are compiled by the Connecticut Department of Transportation (DOT) Accident Records Section from police accident reports made by local officers responding to motor vehicle collisions. The data available for 1995 and 1996 include all motor vehicle collisions occurring on state roads, as well as those collisions occurring on local roads for which the responding officer indicated that the collision had resulted in an injury. The medical record linking is an automated process relying on a probabilistic record-linking software package used by all of the funded CODES projects.

The Connecticut CODES GIS database design includes tables of motor vehicle collision attributes, including the linked data, managed in a Microsoft Access relational database, and databases of collision locations, managed as ArcView (ESRI, Redlands, CA) shapefiles. A unique identifying number links the collision attributes to the points representing their locations. The Planning Section of the Connecticut DOT provided latitude/longitude geocodes for all collisions occurring on state roads. CODES GIS project staff geocoded the collisions that occurred on local roads and projected all crash locations based on the Connecticut Coordinate System, a system of state plane coordinates.

A GIS database of collision locations would not be of much use alone. Additional data incorporated into the Connecticut CODES GIS are a 1995 state road network datalayer from the Connecticut DOT Planning Section and town boundary and annotation layers from the Connecticut Department of Environmental Protection. The 1990 TIGER address-ranged street network database from the US Census Bureau can be used to support finding particular addresses and intersections. For viewing crash data, digital

raster graphics from the US Geological Survey of 7.5-minute quadrangle maps for Connecticut can be used as an alternative to the 1995 state road network datalayer.

Because the Connecticut CODES database is a linked database compiled from records maintained by a variety of agencies, CODES database users do not edit data. Instead, the Connecticut CODES GIS is designed to provide users with a tool for easily displaying, querying, and mapping crash data. These functions are especially important because they support distribution of the public-use version of the database.

A GIS application designed specially for the Connecticut CODES project was created to modify the GIS software package purchased from the vendor. This application cannot be modified by the user. It allows the user to search the linked database by asking "what" or "where" questions (for example, "What are the collisions of interest and where did they occur?" or "Where are the places of interest and what kinds of collisions occurred there?"). The application supports a number of important functions required to answer these questions:

- Displays road network, town boundary, and annotation layers.
- Loads one or more years of crash data selected by the user or a user-defined database and joins and links attribute tables.
- Toggles annotation on/off.
- Toggles digital raster graphics on and off.
- Hides/shows table of contents and legends for motor vehicle crash and other databases.
- Identifies collisions where the user clicks.
- Labels collisions by road name (for road where collision occurred or intersecting road).
- Labels a collision site with a count of collisions that occurred at that location in a particular year.
- Finds and pans to a crash location based on a CODES identifier entered by the user.
- Finds and highlights crashes with characteristics identified by the user.
- Provides a range of tools for graphical selection of collisions at a point, within a rectangle, or within a buffered segment of the road network.
- Prints reports of the attributes of selected collisions.
- Prints color maps of crash locations based on a standard map layout, the display created by the user, and title text entered by the user.
- Adds the address-ranged street network database for the town selected by the user and supports finding a particular address or intersection.

Results

An example of the kind of analysis that would be supported by the Connecticut CODES GIS is an investigation of all collisions in 1995 that involved pedestrians and happened in Norwich, Connecticut. This use of the system would begin with a defined set of collisions of interest. The system can be used to develop numerators and denominators for the town as a whole and for the particular collision of interest. For example, in 1995, motor vehicle injuries in Norwich involving pedestrians represented only a small

percentage of all motor vehicle crashes that occurred, but they were more likely to have linked medical records (Table 1).

Table 1   Comparison of Total and Pedestrian Collisions in Norwich, Connecticut, in 1995

	All Types	Involving Pedestrians
Number of collisions	1,163	24
At least one linked medical record	357	17
No linked medical record	806	7

Using the Connecticut CODES GIS, maps and reports of collisions of interest can be prepared. The standard map output (Figure 1) shows that 3 of the 24 pedestrian collisions of interest occurred near the intersection of Connecticut Route 2 and Talman Street, in the context of 7 other collisions that occurred at that location. The collision count and street name labels are shown on the map.

The report on selected crashes provides information based on a set of variables selected by the user. In this example, seven fields were chosen for the report, including the collision identifier number, a variable that indicates whether at least one person involved in the collision had a linked hospital record, and other basic collision attribute information, including the weekday and time of occurrence, the number of vehicles and pedestrians involved, and the collision type. Figure 2 shows a sample report.

In the public-use version of the database, only limited information is provided from the linked medical record data. Basically, users can determine whether linked medical or mortality records were found for individuals involved in a collision and can ascertain the general nature of the injuries and medical care costs associated with treating them. More detailed medical information is available in the full Connecticut CODES database.

Discussion

The Connecticut CODES GIS is advancing the analysis of motor vehicle injury by allowing analysts to select and map collisions based on a complex set of variables that capture the multidimensional characteristics of collision events. The statewide, multi-year, linked database makes it possible to distinguish, for example, the environmental settings in which motorcyclists are involved in collisions with other vehicles, in contrast to those involving only the motorcyclist, as well as the contributing factors associated with those collisions and the different medical care outcomes of the collisions.

In addition to providing a platform for more meaningful epidemiological studies of motor vehicle injury, the Connecticut CODES project, with its GIS component, provides public health professionals, law enforcement and transportation officials, the general public, and other stakeholders a rich database for designing public health interventions to address the problem of motor vehicle injury in the state. Distribution of the data through a public-use version of the database (which protects confidentiality of medical record information) creates an opportunity for interested parties at the local level to develop prevention strategies based on local needs that may not be reflected in statewide priorities for injury prevention. Armed with data on the types of collisions that are
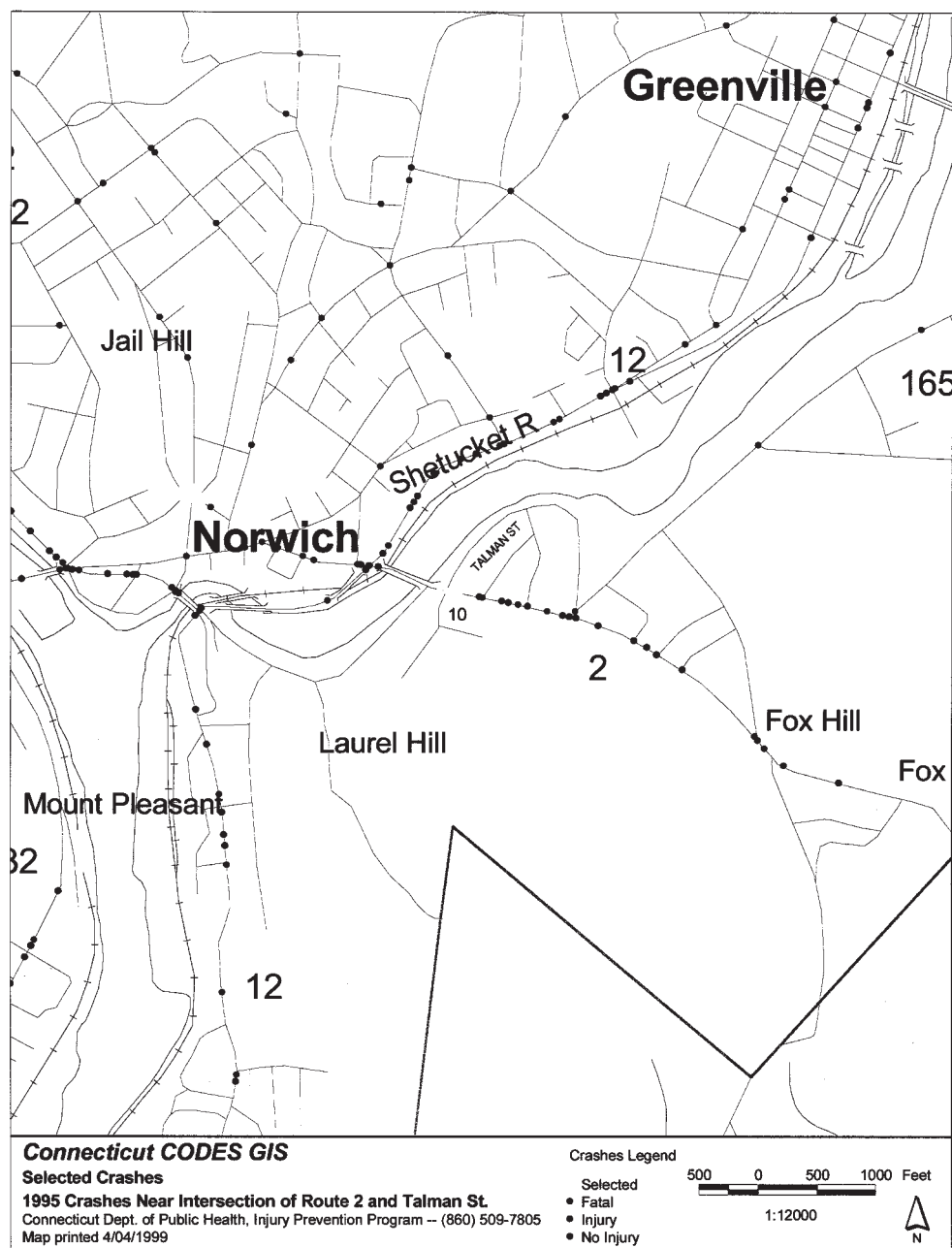
Figure 1   Sample map output from the Connecticut CODES GIS.

Report of Selected Collision Attribute Information

1995 Crashes

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CODES_ID    HOSPLINK WEEKDAY   ACCTIME NUMVEH NUMPED COLLISTYPE
1995101781           Saturday  1615       2      0 Rear-end
1995125135           Thursday  1419       2      0 Turning - Intersecting Paths
1995132971 Yes       Monday    1155       1      1 Pedestrian
1995136910 Yes       Saturday  1200       2      0 Turning - Same Direction
1995139301 Yes       Thursday  2112       1      1 Pedestrian
1995144234 Yes       Wednesday 0705       2      0 Turning - Same Direction
1995145310           Tuesday   1405       1      1 Pedestrian
1995147975 Yes       Monday    1500       2      0 Rear-end
1995152802           Saturday  0900       2      0 Rear-end
1995155309           Thursday  1958       2      0 Rear-end
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Figure 2   Sample report output from the Connecticut CODES GIS.

occurring at high-frequency collision locations in each locality, officials can begin to de-sign intervention programs that tailor operator and pedestrian education, traffic en-forcement, and environmental modifications to the particular types of collisions occurring at particular sites.

Acknowledgments

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